Energy intake and expenditure during sedentary screen time and motion-controlled video gaming[1–3]

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ABSTRACT

Background: Television watching and playing of video games (VGs) are associated with higher energy intakes. Motion-controlled video games (MC) may be a healthier alternative to sedentary screen-based activities because of higher energy expenditures, but little is known about the effects of these games on energy intakes.

Objective: Energy intake, expenditure, and surplus (intake − expenditure) were compared during sedentary (television and VG) and active (MC) screen-time use.

Design: Young adults (n = 120; 60 women) were randomly assigned to the following 3 groups: television watching, playing traditional VGs, or playing MCs for 1 h while snacks and beverages were provided. Energy intakes, energy expenditures, and appetites were measured.

Results: Intakes across these 3 groups showed a trend toward a significant difference (P = 0.065). The energy expenditure ($P < 0.001$) was higher, and the energy surplus (P = 0.038) was lower, in MC than in television or VG groups. All conditions produced a mean (±SD) energy surplus as follows: 638 ± 408 kcal in television, 655 ± 533 kcal in VG, and 376 ± 487 kcal in MC groups. The OR for consuming ≥500 kcal in the television compared with the MC group was 3.2 (95% CI: 1.2, 8.4). Secondary analyses, in which the 2 sedentary conditions were collapsed, showed an intake that was 178 kcal (95% CI: 8, 349 kcal) lower in the MC condition than in the sedentary groups (television and VG).

Conclusion: MCs may be a healthier alternative to sedentary screen time because of a lower energy surplus, but the playing of these games still resulted in a positive energy balance. This trial was registered at clinicaltrials.gov as NCT01523795. *Am J Clin Nutr* 2012;96:234–9.

INTRODUCTION

Sedentary behaviors, such as television watching and the playing of video games (VGs)[4], are highly prevalent (1) and have wide-ranging public health consequences including obesity and related negative health outcomes (2, 3). Preliminary cross-sectional evidence has linked television watching to obesity and energy intakes (4–6). Laboratory studies of eating behaviors have consistently shown an increased energy intake during television watching compared with no stimulus (7–9), even in the absence of food-related advertising (9, 10).

Although television watching remains the most prevalent sedentary behavior (1), video gaming is also quite popular. There is evidence that gaming may ameliorate some of the negative health effects of television watching by replacing sedentary behavior with light (11, 12) or moderate-vigorous physical activity (13, 14). However, increases in energy expenditures may be offset by increased energy intakes. Studies that compared gaming with no distraction have shown similar effects as television-based distraction (15–17), but to our knowledge, no studies have compared television and VGs to one another to determine effects on energy intakes.

The recent popularity of motion-based controllers raises the question of whether VGs may differ from television and also between types of game control. It is possible that the effects of motion-controlled video games (MCs) on energy intakes and expenditure are different from those of typically controlled games (ie, button-based gamepad controllers). MCs could affect energy intakes because of increased energy expenditures or because MCs occupy hands that would otherwise be used to consume snacks. A comparison of snacking during traditional seated gaming or gaming while walking on a treadmill showed no difference in intakes (18), which suggested that differences in energy expenditures during game play may not affect intakes. We are not aware of any published studies that have compared motion-controlled gaming to traditional gaming to investigate the effects of greater hand occupation on snacking behavior.

There is a need for rigorously controlled investigations of the effects of different forms of screen time on energy intake and expenditure. The purpose of this study was to investigate potential differences in energy intake, expenditure, and surplus (the difference between intake and expenditure) associated with 2 sedentary screen behaviors (ie, television watching and traditional VG playing) and one potentially active screen behavior (the playing of MCs). This investigation excluded advertisements and offered a choice of television or VG content, food, and beverages to minimize potential confounding because of individual preferences. It was hypothesized that MCs would be

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[4] Abbreviations used: MC, motion-controlled video game; MET, metabolic equivalent; VG, video game.

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associated with a lower energy intake, higher energy expenditure, and lower energy surplus than would the watching of television or playing of traditional VGs with a handheld gamepad controller.

SUBJECTS AND METHODS

Recruitment

One hundred twenty 18–35-y-old adults (n = 60 men and 60 women) were recruited by using a university mailing list and television advertisements on a local cable news channel. To be eligible for the study, participants were required to weigh <300 pounds (a requirement for one of the game controllers), have played VGs ≥3 times over the previous year, have transportation to the study location, and be willing to fast 2 h before their appointment and be videotaped during their appointment. Of 324 individuals who requested information and eligibility criteria, 199 subjects completed eligibility information; of those 199 subjects, 132 potential participants were scheduled, and 120 participants completed the study protocol. All data were collected between October 2010 and February 2011. Appointments were scheduled to occur near traditional mealtimes for lunch (eg, 1200 or 1400) or dinner (eg, 1600 or 1800). The time of day did not differ across the 3 groups [χ_2^2 = 1.88, P = 0.382].

Procedure

This study was conducted in a dedicated media laboratory in a university-owned building. All media were played on a 58-inch high-definition plasma screen television. Participants provided written informed consent, after which anthropometric and questionnaire measures were taken. Fasting for a period of ≥2 h before the time of the appointment was confirmed. All participants wore an activity monitor on the upper right arm. Participants were randomly assigned to watch television, play traditional VGs, or play MCs. In all 3 groups, shows or games could be changed at the discretion of participants during the 1-h study period.

Television group

Participants (n = 40) watched television programs by using Netflix instant-streaming software (Netflix Inc) via an Internet-connected Xbox 360 console (Microsoft). A wide variety of television shows were available. Participants watched a range of programming types, including action (eg, “24” and “Avatar: The Last Airbender”), comedy (eg, “The Office” and “30 Rock”), drama (eg, “Weeds” and “Dexter”), nature (eg, “Blue Planet” and “Life of Mammals”), and reality (eg, “Say Yes to the Dress” and “Flavor of Love”). This streaming service offers selections from commercially available DVD releases and, thus, does not include advertisements of any kind.

Traditional VG group

Participants (n = 40) played one or more of 10 available VGs on a Playstation 3 console (Sony) (single-player only and not connected to the Internet). Games were chosen to represent as many genres as possible, with ≤2 games from any one genre. All games received ratings of >75 from an online critical ranking aggregator with scores that ranged from 0 (worst) to 100 (best). Scores >75 indicated generally positive reviews from critical and gaming-enthusiast publications. All of the games used a standard Playstation 3 Dualshock controller (Sony), which included 2 analog sticks, a directional pad, 4 primary buttons, and 4 secondary buttons on the controller shoulder. No games included motion control of any kind; all game inputs were based on pressing buttons or moving the analog sticks. Five of the games were rated M for mature, and 5 of the games were rated from E (everyone) to T (teen). The games were *Assassin's Creed 2* (Ubisoft Entertainment SA), *Call of Duty: Modern Warfare 2* (Activision Inc), *Dead Rising 2* (Capcom Entertainment Inc), *Dead Space* (Electronic Arts Inc), *Final Fantasy XIII* (Square Enix Co Ltd), *Little Big Planet* (Sony Computer Entertainment America LLC), *Ratchet & Clank Future: Tools of Destruction* (Sony Computer Entertainment America LLC), *Red Dead Redemption* (Take-Two Interactive Software Inc), *Street Fighter IV* (Capcom Entertainment Inc), and *3D Dot Game Heroes* (Atlus Co Ltd).

MC group

Participants (n = 40) played ≥1 of 10 available VGs on either a Wii (Nintendo) or Xbox 360 (Microsoft) console (single-player only and not connected to the Internet). Games were included that required at least arm motions to play (at least throwing or hitting motions). Because this study was specifically focused on games, it did not include fitness-themed games that were based on exercises with no game (eg, strategic or narrative) content. The games were *Boom Blox Bash Party* (Electronic Arts Inc; throwing motions), *Dance Dance Revolution: Universe 2* (Konami Digital Entertainment Inc; jumping and dancing motions), *NHL Slapshot* (Electronic Arts Inc; swinging motions), *Punch-Out!!* (Nintendo of America Inc; punching motions), *Rayman Raving Rabbids: TV Party* (Ubisoft Entertainment SA; dancing, swinging, and throwing motions), *Rock Band 2* (Electronic Arts Inc; drumming motions), *Wario Ware: Smooth Moves* (Nintendo of America Inc; throwing motions), *We Cheer 2* (Namco Bandai Games America Inc; dancing motions), *Wii Fit Plus* (Nintendo of America Inc; jogging, throwing, and leaning motions), and *Wii Sports Resort* (Nintendo of America Inc; throwing, punching, and swinging motions). A Wii Remote and nunchuk (Nintendo), dance mat, hockey stick, balance board, and drum set were the controllers available for use.

Snacks and beverages

During the study period, snacks and beverages were made available. Snacks were placed on a table alongside the chair of the participant, which was placed ∼6 feet from the television. Four clear plastic containers (16-cup/3.8-L capacity) were placed on the table with small plastic bowls in front of each. The snacks available were M & M's candy (Mars Inc; regular), Baked Lay's and Doritos chips (Frito-Lay North America Inc), and Trader Joe's Simply the Best Trek Mix (Trader Joe's Co; which consisted of cashews, almonds, dried pineapples, cranberries, and cherries). Snacks were chosen on the basis of pilot data on snack and beverage preferences of young adult gamers (Lyons, unpublished data, 2009) and to include 2 savory and 2 sweet options. Three bottles or cans each of water, Coca-Cola, Diet Coke (both Coca-Cola Co), and Mountain Dew (Pepsi-Co) were available in a refrigerator placed next to the chair of the participant.

Measures

Energy intakes were measured by weighing food and beverage containers to the nearest gram before and after each session by using a digital food scale (Tanita). Energy expenditures were measured by using a SenseWear Pro armband (BodyMedia Inc) on the upper right arm. The SenseWear Pro armband uses accelerometry as well as a galvanic skin response to estimate energy expenditures. The armband has shown an adequate validity in physical activity measurement (19) and has been used in laboratory-based VG studies (20). Heights and weights were measured with subjects wearing light street clothes without shoes by using a wall-mounted stadiometer (Perspective Enterprises Inc) and calibrated scale (Tanita).

Appetite was measured by using items from Bellisimo et al (8). Participants responded to 4 questions on hunger, fullness, desire to eat, and prospective food consumption by using a 200-mm visual analog scale with anchors at either end (an example item was "How strong is your desire to eat?" with anchors "very weak" and "very strong"). The appetite score was calculated by adding hunger, desire to eat, prospective food consumption, and 200 minus fullness and then dividing by 4 to produce an appetite score between 1 and 200 [hunger + desire to eat + prospective food consumption + (200 − fullness)/4].

Data analysis

The total weight for each food and beverage consumed was measured by subtracting the weight of food or beverage containers at the conclusion of the study period from the weight measured before the study period. Kilocalories per gram were calculated by using reported nutrition information from food and beverage packaging. The energy expenditure in kilocalories was measured over the entire 1-h study period. Kilocalories per kilogram of body weight per hour, which was equal to metabolic equivalents (METs), were calculated and used to assign the activity intensity (sedentary behavior: <1.5 METs; light-intensity physical activity: 1.5–2.9 METs; and moderate-intensity physical activity: 3–5.9 METs) (21). The energy surplus was calculated as the energy expenditure subtracted from the energy intake.

All statistical analyses were performed with SAS 9.2 software (SAS Inc). Nonparametric ANCOVAs were performed to test hypotheses (22, 23). This method needed only minimal assumptions beyond randomization in the study design. The sample size was sufficient to apply a large sample approximation. The Markov chain Monte Carlo method was used to impute missing data (10 copies) (24). A Markov chain is a sequence of random variables in which the distribution of each element depends only on the value of the previous one. Markov chain Monte Carlo simulation constructs a long Markov chain to establish a stationary distribution, which is the distribution of interest. By repeatedly simulating steps of the chain, the method draws imputed estimates from the distribution. Results from imputations were combined on the basis of the method proposed by Rubin (25). Correlations were performed to test associations between variables. Adjustment for sex was included in all ANCOVA models. A contrast that involved MC and traditional VG compared with television (ie, 2MC – VG – television) was specified as the global assessment. If a global test was significant, pairwise comparisons were examined with Bonferroni adjustment for managing multiplicity. Logistic regression was used to investigate the likelihood of consuming >500 kcal.

As a secondary analysis, the 2 sedentary conditions (television watching and traditional VG; METs <1.5) were collapsed. The collapsed group was used as a reference in the comparison with the MC group.

RESULTS

Participant characteristics

Means (±SDs) for participant characteristics are displayed in **Table 1**. Sixty-two percent of the sample was white, 17% of the sample was black, 14% of the sample was Asian, 7% of the sample was classified as other, and 8% of the sample reported Hispanic ethnicity. Most participants were normal weight (63%), 26% of participants were overweight, and 11% of participants were obese, with a mean BMI (in kg/m^2) of 24.4 ± 4.1 and a mean age of 24.1 ± 4.4 y. Participants reported ∼2.5 h/d of combined television watching and VG playing. No significant differences were shown between groups for any demographic variables. Height and weight differed by sex (P < 0.001), but BMI did not differ by sex (P = 0.230). Self-reported appetite did not differ by group at the start of the study (P = 0.325).

Energy intake, expenditure, and surplus

When total energy intakes between the 3 groups were compared, a trend toward a significant difference was shown (P = 0.065; **Table 2**). Overall, participants consumed a mean of 672 ± 488 kcal from foods and beverages during the 1-h study period. Logistic regression analysis showed that consuming >500 kcal (n = 65) was predicted by male sex (OR: 3.2; 95% CI: 1.3, 7.9) and watching television (compared with in the MC group, OR: 3.2; 95% CI: 1.2, 8.4). No difference was shown between VG and MC groups (OR: 1.6; 95% CI: 0.6, 4.0). Not consuming any calories (n = 9; 7 women; 5 overweight subjects) was rare.

In the secondary analysis, we collapsed the 2 sedentary conditions to compare them to motion-controlled active gaming. The comparison of sedentary to active screen time showed a significant difference (P < 0.001). Participants who played MCs consumed 179 kcal (95% CI: 8, 349 kcal) less than did subjects who engaged in sedentary screen time. Men consumed 353 kcal (95% CI: 193, 514 kcal) more than did women (P < 0.001). Adjustment of the model for BMI or height did not alter findings (P = 0.033). For the 2-group logistic regression, the comparison of sedentary screen time to motion-controlled gaming showed a trend toward significance for the consumption of ≥500 kcal (OR: 2.21; 95% CI: 0.97, 5.02; P = 0.058).

A comparison of energy expenditures showed a significant difference between the 3 groups (P < 0.001). When multiplicity adjustment was considered, the MC group produced a significantly higher energy expenditure than that of both the television group (mean difference: 1.42 kcal · kg^{-1} · h^{-1}; 95% CI: 1.18, 1.66 kcal · kg^{-1} · h^{-1}; P < 0.001) and VG group (mean difference: 1.20 kcal · kg^{-1} · h^{-1}; 95% CI: 0.95, 1.45 kcal · kg^{-1} · h^{-1}; P < 0.001). A higher energy expenditure in the VG group than in the television group was also shown (mean difference: 0.22 kcal · kg^{-1} · h^{-1}; 95% CI: 0.11, 0.33 kcal · kg^{-1} · h^{-1}; P = 0.001), although traditional VGs were still sedentary (1.30 METs). After adjustment for group and BMI, men produced 0.23 kcal · kg^{-1} · h^{-1} (95% CI: 0.04, 0.41 kcal · kg^{-1} · h^{-1}) more than women did (P = 0.015). The secondary analysis also showed a significant difference in energy expenditure (mean difference: 1.31 kcal · kg^{-1} · h^{-1}; 95% CI: 1.07, 1.55 kcal · kg^{-1} · h^{-1}; P < 0.001) between sedentary screen time and MCs.

Energy surplus, which was operationalized as energy intake minus energy expenditure, showed a similar pattern to energy expenditure. When the 3 groups were compared, energy surplus differed significantly ($P = 0.038$) such that the energy surplus was lower in the MC group than in the television group (mean difference: −263 kcal; 95% CI: −452, −73 kcal; $P = 0.006$) and VG group (mean difference: −279 kcal; 95% CI: −480, −78 kcal; $P = 0.007$), which were significant after multiplicity adjustment by using the Bonferroni method. The 2-group comparison in the secondary analysis was also significant ($P = 0.002$), in which the MC group produced 271-kcal lower energy surplus (95% CI: 101, 441 kcal) than did the sedentary screen time group. The energy surplus was 317 kcal greater (95% CI: 155, 479 kcal) in men than in women ($P < 0.001$). Most ($n = 108$) of the 120 participants were in a positive energy balance at the conclusion of the 1-h study period (range: −304 to 1923 kcal).

Energy intake and energy expenditure were unrelated when analyzed by using the full sample ($r = -0.04$, $P = 0.666$) and when analyzed separately for each group (television: $r = 0.10$, $P = 0.53$; VG: $r = 0.00$, $P = 0.989$; and MC: $r = 0.27$, $P = 0.089$). BMI was not related to intake ($r = -0.02$, $P = 0.824$) but showed a trend toward an association with body mass–corrected expenditure ($r = -0.17$, $P = 0.070$). The association between height-adjusted energy intake and weight was not significant ($r = -0.31$, $P = 0.735$). Age was not related to intake ($r = -0.14$, $P = 0.115$) or expenditure ($r = -0.11$, $P = 0.237$). Race did not predict intake ($P = 0.092$) or expenditure ($P = 0.983$).

There was no difference between groups ($P = 0.883$) for poststudy appetite, and the change in appetite from before to after the study period also showed no difference by group ($P = 0.291$). Appetite before the study period was positively associated with energy intake ($r = 0.467$, $P < 0.001$), whereas poststudy appetite ($r = -0.384$, $P < 0.001$) and change in appetite ($r = -0.571$, $P < 0.001$) were negatively associated with energy intake. Prestudy, poststudy, and change in appetite were not associated with energy expenditure ($P > 0.50$), and the results did not differ by group.

DISCUSSION

No significant differences in the 3 groups were shown for energy intake. However, a trend toward a significant difference was shown ($P = 0.065$), and the energy expenditure was significantly higher and the energy surplus significantly lower in the MC group than in the television and traditional video-gaming groups. In addition, in secondary analyses, when motion-controlled gaming was contrasted with sedentary screen time (television watching and traditional video gaming), differences in energy intakes were significant. We hypothesize that this difference in results was due to issues related to statistical power. Greater variability reduces power, and we showed greater variability than has been reported in previous studies of snacking during television watching (8, 26).

Participants in this study showed a mean energy surplus of 555 kcal, which meant that they consumed, on average, more energy during the 1-h study period than they expended; however, subjects who played MCs had an energy surplus that was 273 kcal lower than in the sedentary screen groups. Participants who watched television were more likely than participants who played MCs to consume ≥500 kcal during the 1-h study period. Results from the current study suggested that MCs may reduce the positive energy balance associated with sedentary screen time.

TABLE 1
Participant characteristics[1]

	Television (n = 40)			Video games (n = 40)			Motion-controlled video games (n = 40)			
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Total (n = 120)
Age (y)	26.1 ± 4.7	23.2 ± 4.3	24.6 ± 4.7	22.8 ± 4.8	24.4 ± 3.8	23.6 ± 4.2	23.8 ± 4.8	24.3 ± 4.2	24.0 ± 4.4	24.1 ± 4.4
Height (cm)	177.2 ± 7.7	165.0 ± 5.2	171.1 ± 9.0	179.9 ± 8.8	163.7 ± 6.3	171.8 ± 11.1	163.4 ± 6.4	179.9 ± 8.8	170.1 ± 9.2	171.0 ± 9.8*
Weight (kg)	82.3 ± 17.4	62.9 ± 9.8	72.6 ± 17.1	79.4 ± 13.1	64.6 ± 15.5	72.0 ± 16.0	74.4 ± 10.7	65.6 ± 9.5	70.0 ± 10.9	71.5 ± 14.8*
BMI (kg/m^2)	26.3 ± 5.0	23.1 ± 3.6	24.7 ± 4.6	24.6 ± 3.1	24.0 ± 4.9	24.3 ± 4.0	23.9 ± 3.1	24.7 ± 4.5	24.3 ± 4.2	24.4 ± 4.1
Appetite										
Before	111.4 ± 36.2	134.0 ± 20.4	122.7 ± 31.2	124.8 ± 33.6	115.7 ± 29.1	120.3 ± 31.3	120.2 ± 31.1	105.1 ± 33.8	112.7 ± 33.0	118.5 ± 31.9
After	79.1 ± 37.3	68.5 ± 35.1	73.8 ± 36.1	79.8 ± 31.0	69.2 ± 39.4	74.6 ± 35.3	75.7 ± 32.1	77.6 ± 37.2	76.7 ± 34.3	75.0 ± 35.0

[1] All values are means ± SDs. Differences were tested by using 2-way (sex and group assignment) ANCOVA. * Significant difference between sexes, $P < 0.05$.

Compared with eating without distraction, television watching and gaming have consistently been shown to produce increases in energy intakes (15–17). Comparisons of different media have produced various results. In 2 studies, television watching and an audio recording of a detective story were shown to produce equivalent energy intakes (27, 28), and a comparison of seated traditional gaming to traditional gaming while walking on a treadmill also showed equivalent intakes (18). However, a comparison of television watching to listening to a symphony showed a greater intake in the television group (26), and a comparison of continuous television watching with watching a television segment repeatedly showed a greater intake in the continuous group (10). The hypothesized mechanism by which these media influence intake is distraction from satiety cues (10).

It is possible that continuous television watching produces greater narrative transportation (29) than watching a repeated segment or listening to classical music, which may have led to increased distraction from satiety cues. Narrative transportation is the feeling of being immersed and absorbed in a story, which may be associated with distraction from real-world stimuli. In this study, MCs may have produced lower feelings of transportation than did television or traditional VGs. None of the included MCs included an involved storyline, whereas many of the traditional games and television shows emphasized their narrative contents. It is also possible that motion controllers could discourage snacking because of the possibility that the game could interpret eating movements as intended game inputs, which could result in poorer performance. The lack of an association between energy expenditure and energy intake suggests that it was not the intensity of the activity that produced a lower intake. Additional study is necessary to investigate variables that may explain effects of different screen-based media on eating behaviors. The use of camera-based motion control, such as Xbox 360 Kinect games (Microsoft), may produce differing results than those shown in the current study from handheld motion control.

It has been reported that 36% of eating occasions in young adults occur while multitasking (ie, while distracted) (30). It does not appear that the substitution of traditional video gaming with television watching affects energy intakes, but the substitution of motion-controlled gaming may have a beneficial effect on both sides of the energy-balance equation. Because of the widespread use of television and VG technology as well as the prevalence of eating while distracted by these media, the replacement of television watching or traditional video gaming with motion-controlled gaming has the potential for a broad public health impact. However, such replacement would be a harm-reduction strategy because motion-controlled gaming produced a large ~400-kcal–positive energy balance.

Despite the many strengths of this study, results should be interpreted in light of several limitations. Laboratory conditions cannot accurately replicate in-home media consumption and snacking behaviors. Results from this study should not be taken as representative of the amount consumed during typical screen-based leisure activities. The presence of highly palatable snack foods and beverages offered at no cost likely produced greater intakes than might be expected typically. An observational study in the home environment or studies of screen-based media use while participants eat self-purchased snacks or meals may provide more precise estimates. Some other studies have investigated effects of VGs on subsequent eating instances (15, 16); in this

TABLE 2
Outcomes across groups and sexes[1]

	Television (n = 40)			Video games (n = 40)			Motion-controlled video games (n = 40)		
	Men	Women	Total	Men	Women	Total	Men	Women	Total
Food intake (kcal)	691 ± 403	615 ± 367	653 ± 382	899 ± 535	452 ± 418	675 ± 525	697 ± 558	307 ± 254	502 ± 472
Soda intake (kcal)	73 ± 89	54 ± 76	63 ± 82	114 ± 107	28 ± 67	71 ± 98	73 ± 93	29 ± 68	51 ± 84
Total intake (kcal)	764 ± 424	669 ± 396	716 ± 407	1013 ± 504	481 ± 442	747 ± 540	769 ± 571	336 ± 290	553 ± 498
Energy expenditure ($kcal \cdot kg^{-1} \cdot h^{-1}$)	1.08 ± 0.13	1.06 ± 0.11	1.07 ± 0.12*	1.36 ± 0.22	1.24 ± 0.35	1.30 ± 0.29*	2.72 ± 0.76	2.29 ± 0.73	2.50 ± 0.77
Energy surplus (kcal/h)	676 ± 431	603 ± 393	638 ± 408*	906 ± 505	404 ± 442	655 ± 533*	565 ± 564	187 ± 305	376 ± 487

[1] All values are means ± SDs. Differences were tested by using nonparametric ANCOVA adjusted for sex and pairwise comparisons with Bonferroni adjustment as necessary. Significant differences between sexes are shown for all variables, $P < 0.01$ *Significantly less than for motion-controlled video games, $P < 0.05$.

study, we evaluated intakes only during exposure to the media studied. Although evidence on the effects of exercise on appetite is mixed (31), it is possible that the playing of MCs could produce later compensatory eating in some individuals, which would attenuate the benefits of MCs on energy balance.

The instrument used to measure energy expenditure (ie, the SenseWear Pro armband; BodyMedia Inc) is a valid measure but not the gold standard of expenditure measurement. Thus, energy-expenditure estimates may have been less precise than if they had been measured by indirect calorimetry. Exercise- and fitness-themed games were not included, and these games may produce different results than those of other MCs. In addition, MCs vary in their content and the extent to which motions are integrated into gameplay. Additional investigation is needed to determine whether differences in this type of game affect energy intake. The television programs used in this study were streamed rather than watched live; the watching of network or cable television, which includes commercial breaks, may also produce different results.

In conclusion, MCs hold promise as a healthier alternative to sedentary screen time such as television watching and traditional VG playing because of a lower energy surplus. MCs may also be capable of producing health benefits associated with reduced sedentary behavior and increased physical activity. However, participants in the MC group, like those in the sedentary screen time groups, were in a positive energy balance after 1 h of play. Although less harmful than sedentary screen time, playing MCs should not be assumed to produce a net benefit on weight or health. Snacking on energy-dense sweet and savory foods and sodas during screen time was consistently associated with positive energy balances across the 3 conditions. There is a need for more research into the potential benefits as well as possible drawbacks of integrating motion control into VGs.

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